Reading Material
Class IX (2025-26)
Science 086

Section 1
Why Do We Fall Ill
Activity 1.1

- We have all heard of the earthquakes in Latur, Bhuj, Kashmir etc. or the cyclones that attack the coastal regions. Think of as many different ways as possible in which people's health would be affected by such a disaster if it took place in our neighbourhood.
- How many of these ways we can think of are events that would occur when the disaster is actually happening?
- How many of these health-related events would happen long after the actual disaster, but would still be because of the disaster?
- Why would one effect on health fall into the first group, and why would another fall into the second group?

When we do this exercise, we realise that health and disease in human communities are very complex issues, with many interconnected causes. We also realise that the ideas of what 'health' and 'disease' mean are themselves very complicated. When we ask what causes diseases and how we prevent them, we have to begin by asking what these notions mean.

We have seen that cells are the basic units of living beings. Cells are made of a variety of chemical substances – proteins, carbohydrates, fats or lipids, and so on. Although the pictures look quite static, in reality the living cell is a dynamic place. Something or the other is always happening. Cells move from place to place. Even in cells that do not move, there is repair going on. New cells are being generated from existing cells. In our organs or tissues, there are various specialised activities going on – the heart is beating, the lungs are breathing, the kidney is filtering urine, the brain is thinking.

All these activities are interconnected. For example, if the kidneys are not filtering urine, poisonous substances will accumulate in the body. Under such conditions, the brain will not be able to think properly. For all these interconnected activities, energy and raw material are needed from outside the body. In other words, food is a necessity for cell and tissue functions. Anything that prevents proper functioning of cells and tissues will lead to a lack of proper activity of the body.

It is in this context that we will now look at the notions of health and disease.

1.1 Health and Its Failure
1.1.1 The Significance of 'Health'

We have heard the word 'health' used quite frequently all around us. We use it ourselves as well, when we say things like 'my grandmother's health is not good'. Our teachers use it when they scold us saying 'this is not a healthy attitude'. What does the word 'health' mean?

If we think about it, we realise that it always implies the idea of 'being well'. We can think of this well-being as effective functioning. For our grandmothers, being able to go out to the market or to visit neighbours is 'being well', and not being able to do such things is 'poor health'. Being interested in following the teaching in the classroom so that we can understand the world is called a 'healthy attitude'; while not being interested is called the opposite. 'Health' is therefore a state of being well enough to function well physically, mentally and socially.

1.1.2 PERSONAL AND COMMUNITY ISSUES BOTH MATTER FOR HEALTH

If health means a state of physical, mental and social well-being, it cannot be something that each one of us can achieve entirely on our own. The health of all organisms will depend on their surroundings or their environment. The environment includes the physical environment. So, for example, health is at risk in a cyclone in many ways. But even more importantly, human beings live in societies. Our social environment, therefore, is an important factor in our individual health. We live in villages, towns or cities. In such places, even our physical environment is decided by our social environment. Consider what would happen if no agency is ensuring that garbage is collected and disposed. What would happen if no one takes responsibility for clearing the drains and ensuring that water does not collect in the streets or open spaces? So, if there is a great deal of garbage thrown in our streets, or if there is open drainwater lying stagnant around where we live, the possibility of poor health increases. Therefore, public cleanliness is important for individual health.

Activity 1.2

- Find out what provisions are made by your local authority (panchayat/ municipal corporation) for the supply of clean drinking water.
- Are all the people in your locality able to access this?

Activity 1.3

- Find out how your local authority manages the solid waste generated in your neighbourhood.
- Are these measures adequate?
- If not, what improvements would you suggest?
- What could your family do to reduce the amount of solid waste generated during a day/week?

We need food for health, and this food will have to be earned by doing work. For this, the opportunity to do work has to be available. Good economic conditions and jobs are therefore needed for individual health. We need to be happy in order to be truly healthy, and if we mistreat each other and are afraid of each other, we cannot be happy or healthy. Social equality and harmony are therefore necessary for individual health. We can think of many other such examples of connections between community issues and individual health.

1.1.3 DISTINCTIONS BETWEEN 'HEALTHY' AND 'DISEASE-FREE'

If this is what we mean by 'health', what do we mean by 'disease'? The word is actually self-explanatory – we can think of it as 'disease' – disturbed ease. Disease, in other words, literally means being uncomfortable. However, the word is used in a more limited meaning. We talk of disease when we can find a specific and particular cause for discomfort. This does not mean that we have to know the absolute final cause; we can say that someone is suffering from diarrhoea without knowing exactly what has caused the loose motions.

We can now easily see that it is possible to be in poor health without actually suffering from a particular disease. Simply not being diseased is not the same as being healthy. 'Good health' for a dancer may mean being able to stretch her body into difficult but graceful positions. On the other hand, good health for a musician may mean having enough breathing capacity in his/her lungs to control the notes from his/her flute. To have the opportunity to realise the unique potential in all of us is also necessary for real health.

So, we can be in poor health without there being a simple cause in the form of an identifiable disease. This is the reason why, when we think about health, we think about societies and communities. On the other hand, when we think about disease, we think about individual sufferers.

Questions

1. State any two conditions essential for good health.
2. State any two conditions essential for being free of disease.
3. Are the answers to the above questions necessarily the same or different? Why?

1.2 Disease and Its Causes

1.2.1 WHAT DOES DISEASE LOOK LIKE?

Let us now think a little more about diseases. In the first place, how do we know that there is a disease? In other words, how do we know that there is something wrong with the body? There are many tissues in the body. These tissues make up physiological systems or organ systems that carry out body functions. Each of the organ systems has specific organs as its parts, and it has particular functions. So, the digestive system has the stomach and intestines, and it helps to digest food taken in from outside the body. The musculoskeletal system, which is made up of bones and muscles, holds the body parts together and helps the body move.

When there is a disease, either the functioning or the appearance of one or more systems of the body will change for the worse. These changes give rise to symptoms and signs of disease. Symptoms of disease are the things we feel as being 'wrong'. So we have a headache, we have cough, we have loose motions, we have a wound with pus; these are all symptoms. These indicate that there may be a disease, but they don't indicate what the disease is. For example, a headache may mean just examination stress or, very rarely, it may mean meningitis, or any one of a dozen different diseases. Signs of disease are what physicians will look for on the basis of the symptoms. Signs will give a little more definite indication of the presence of a particular disease. Physicians will also get laboratory tests done where necessary to pinpoint the disease further.

1.2.2 ACUTE AND CHRONIC DISEASES

The manifestations of disease will be different depending on a number of factors. One of the most obvious factors that determine how we perceive the disease is its duration. Some diseases last for only very short periods of time, and these are called acute diseases. We all know from experience that the common cold lasts only a few days. Other ailments can last for a long time, even as much as a lifetime, and are called chronic diseases. An example is the infection causing elephantiasis, which is common in some parts of India.

Activity 1.4

- Survey your neighbourhood to find out:
  (1) how many people suffered from acute diseases during the last three months,
  (2) how many people suffered from chronic diseases during this same period,
  (3) and finally, the total number of people suffering from various diseases in your neighbourhood.
- Are the answers to questions (1) and (2) different?
- Are the answers to questions (2) and (3) different?
- What do you think could be the reason for these differences? What do you think would be the effect of these differences on the general health of the population?

1.2.3 CHRONIC DISEASES AND POOR HEALTH

As we can imagine, acute and chronic diseases have different effects on our health.
Any disease that causes poor functioning of some part of the body will affect our general health as well. This is because all functions of the body are necessary for general health. But an acute disease, which is over very soon, will not have time to cause major effects on general health, while a chronic disease will do so.
As an example, think about a cough and cold, which all of us have from time to time.
Most of us get better and become well within a week or so. And there are no bad effects on our health. We do not lose weight, we do not become short of breath, we do not feel tired all the time because of a few days of cough and cold. But if we get infected with a chronic disease such as tuberculosis of the lungs, then being ill over the years does make us lose weight and feel tired all the time. We may not go to school for a few days if we have an acute disease. But a chronic disease will make it difficult for us to follow what is being taught in school and reduce our ability to learn. In other words, we are likely to have prolonged general poor health if we have a chronic disease. Chronic diseases therefore, have very drastic long-term effects on people’s health as compared to acute diseases.

1.2.4 CAUSES OF DISEASES

What causes disease? When we think about causes of diseases, we must remember that there are many levels of such causes. Let us look at an example. If there is a baby suffering from loose motions, we can say that the cause of the loose motions may be an infection with a virus. So the immediate cause of the disease is a virus.

But the next question is – where did the virus come from? Suppose we find that the virus came through unclean drinking water. But many babies must have had this unclean drinking water. So, why is it that one baby developed loose motions when the other babies did not?

One reason might be that this baby is not healthy. As a result, it might be more likely to have disease when exposed to risk, whereas healthier babies would not. Why is the baby not healthy? Perhaps because it is not well nourished and does not get enough food. So, lack of good nourishment becomes a second level cause of the disease the baby is suffering from. Further, why is the baby not well nourished? Perhaps because it is from a household which is poor.

It is also possible that the baby has some genetic difference that makes it more likely to suffer from loose motions when exposed to such a virus. Without the virus, the genetic difference or the poor nourishment alone would not lead to loose motions. But they do become contributory causes of the disease.

Why was there no clean drinking water for the baby? Perhaps because the public services are poor where the baby's family lives. So, poverty or lack of public services become third-level causes of the baby's disease.

It will now be obvious that all diseases will have immediate causes and contributory causes. Also, most diseases will have many causes, rather than one single cause.

1.2.5 INFECTIOUS AND NON-INFECTIOUS CAUSES

As we have seen, it is important to keep public health and community health factors in mind when we think about causes of diseases. We can take that approach a little further. It is useful to think of the immediate causes of disease as belonging to two distinct types. One group of causes is the infectious agents, mostly microbes or micro-organisms. Diseases where microbes are the immediate causes are called infectious diseases. This is because the microbes can spread in the community, and the diseases they cause will spread with them.

Things to ponder

1. Do all diseases spread to people coming in contact with a sick person?
2. What are the diseases that are not spreading?
3. How would a person develop those diseases that don't spread by contact with a sick person?

On the other hand, there are also diseases that are not caused by infectious agents. Their causes vary, but they are not external causes like microbes that can spread in the community. Instead, these are mostly internal, non-infectious causes.

For example, some cancers are caused by genetic factors. High blood pressure can be caused by excessive weight and lack of exercise. You can think of many other diseases where the immediate causes will not be infectious.

Peptic ulcers and the Nobel prize

For many years, everybody used to think that acidity, which caused peptic ulcers and related pain and bleeding in the stomach and duodenum, were because of lifestyle reasons. Everybody thought that a stressful life led to a lot of acid secretion in the stomach, and eventually caused peptic ulcers.

Then two Australians made a discovery that a bacterium, Helicobacter pylori, was responsible for peptic ulcers. Robin Warren (born 1937), a pathologist from Perth, Australia, saw these small curved bacteria in the lower part of the stomach in many patients. He noticed that signs of inflammation were always present around these bacteria. Barry Marshall (born 1951), a young clinical fellow, became interested in Warren's findings and succeeded in cultivating the bacteria from these sources.

In treatment studies, Marshall and Warren showed that patients could be cured of peptic ulcer only when the bacteria were killed off from the stomach. Thanks to this pioneering discovery by Marshall and Warren, peptic ulcer disease is no longer a chronic, frequently disabling condition, but a disease that can be cured by a short period of treatment with antibiotics.

For this achievement, Marshall and Warren (seen in the picture) received the Nobel prize for physiology and medicine in 2005.

The ways in which diseases spread, and the ways in which they can be treated and prevented at the community level would be different for different diseases. This would depend a lot on whether the immediate causes are infectious or non-infectious.

Questions

1. *List any three reasons why you would think that you are sick and ought to see a doctor. If only one of these symptoms were present, would you still go to the doctor? Why or why not?*
2. *In which of the following case do you think the long-term effects on your health are likely to be most unpleasant?*
   - *if you get jaundice,*
   - *if you get lice,*
   - *if you get acne. Why?*

1.3 Infectious Diseases

1.3.1 INFECTIOUS AGENTS

We have seen that the entire diversity seen in the living world can be classified into a few groups. This classification is based on common characteristics between different organisms. Organisms that can cause disease are found in a wide range of such categories of classification. Some of them are viruses, some are bacteria, some are fungi, some are single-celled animals or protozoans. Some diseases are also caused by multicellular organisms, such as worms of different kinds.

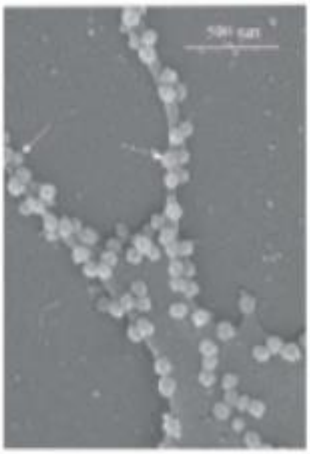

***Fig 1.1 (a)**: Picture of SARS viruses coming out (see arrows for examples) of the surface of infected cell. The white scale line represents 500 nanometres, which is one thousandth of a millimetre. The scale line gives us an idea of how small the things we are looking at are.*
***Courtesy**: Emerging Infectious Diseases, a journal of CDC, US*

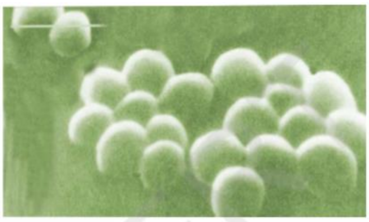

***Fig 1.1 (b)**: Picture of staphylococci, the bacteria which can cause acne. The scale of the image is indicated by the line at top left, which is 5 micrometres long.*

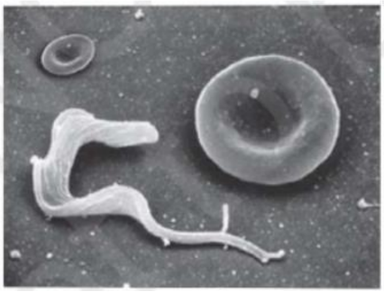

***Fig 1.1 (c)**: Picture of Trypanosoma the protozoan organism responsible for sleeping sickness. The organism is lying next to a saucer-shaped red blood cell to give an idea of the scale.*
Copyright: Oregon Health and Science University, U.S.

***Fig 1.1 (d)**: Picture of Leishmania, the protozoan organism that causes kala-azar. The organisms are oval-shaped, and each has one long whip-like structure. One organism (arrow) is dividing, while a cell of the immune system (lower right) has gripped on the two whips of the dividing organism and is sending cell processes up to eat up the organism. The immune cell is about ten micrometres in diameter.*

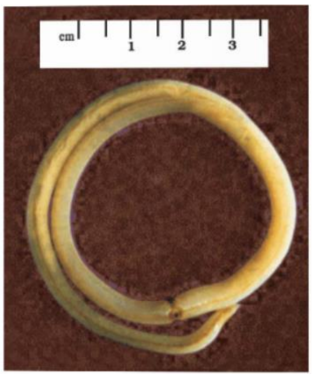

***Fig 1.1 (e)**: Picture of an adult roundworm (Ascaris lumbricoides is the technical name) from the small intestine. The ruler next to it shows intestine. The ruler next to it shows four centimetres to give us an idea of the scale.*

Common examples of diseases caused by viruses are the common cold, influenza, dengue fever and AIDS. Diseases like typhoid fever, cholera, tuberculosis and anthrax are caused by bacteria. Many common skin infections are caused by different kinds of fungi. Protozoan microbes cause many familiar diseases, such as malaria and kalaazar. All of us have also come across intestinal worm infections, as well as diseases like elephantiasis caused by different species of worms.

Why is it important that we think of these categories of infectious agents? The answer is that these categories are important factors in deciding what kind of treatment to use. Members of each one of these groups – viruses, bacteria, and so on – have many biological characteristics in common.

All viruses, for example, live inside host cells, whereas bacteria very rarely do so. Viruses, bacteria and fungi multiply very quickly, while worms multiply very slowly in comparison. Taxonomically, all bacteria are closely related to each other than to viruses and vice versa. This means that many important life processes are similar in the bacteria group but are not shared with the virus group. As a result, drugs that block one of these life processes in one member of the group is likely to be effective against many other members of the group. But the same drug will not work against a microbe belonging to a different group.

As an example, let us take antibiotics. They commonly block biochemical pathways important for bacteria. Many bacteria, for example, make a cell-wall to protect themselves. The antibiotic penicillin blocks the bacterial processes that build the cell wall. As a result, the growing bacteria become unable to make cell-walls, and die easily. Human cells don’t make a cell-wall anyway, so penicillin cannot have such an effect on us. Penicillin will have this effect on any bacteria that use such processes for making cell-walls. Similarly, many antibiotics work against many species of bacteria rather than simply working against one.

But viruses do not use these pathways at all, and that is the reason why antibiotics do not work against viral infections. If we have a common cold, taking antibiotics does not reduce the severity or the duration of the disease. However, if we also get a bacterial infection along with the viral cold, taking antibiotics will help. Even then, the antibiotic will work only against the bacterial part of the infection, not the viral infection.

Activity 1.5

- Find out how many of you in your class had cold/cough/fever recently.
- How long did the illness last?
- How many of you took antibiotics (ask your parents if you had antibiotics)?
- How long were those who took antibiotics ill?
- How long were those who didn’t take antibiotics ill?
- Is there a difference between these two groups?
- If yes, why? If not, why not?

1.3.2 Means of spread

How do infectious diseases spread? Many microbial agents can commonly move from an affected person to someone else in a variety of ways. In other words, they can be ‘communicated’, and so are also called communicable diseases.

Such disease-causing microbes can spread through the air. This occurs through the little droplets thrown out by an infected person who sneezes or coughs. Someone standing close by can breathe in these droplets, and the microbes get a chance to start a new infection. Examples of such diseases spread through the air are the common cold, pneumonia and tuberculosis.

We all have had the experience of sitting near someone suffering from a cold and catching it ourselves. Obviously, the more crowded our living conditions are, the more likely it is that such airborne diseases will spread.

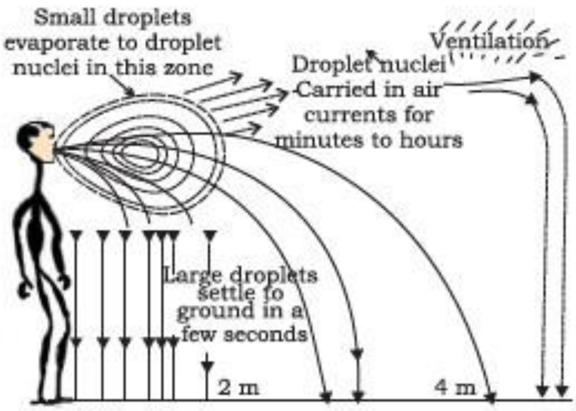

Fig. 1.2**:** *Air-transmitted diseases are easier to catch the closer we are to the infected person. However, in closed areas, the droplet nuclei recirculate and pose a risk to everybody. Overcrowded and poorly ventilated housing is therefore a major factor in the spread of airborne diseases*

Diseases can also be spread through water. This occurs if the excreta from someone suffering from an infectious gut disease, such as cholera, get mixed with the drinking water used by people living nearby. The cholera causing microbes will enter new hosts through the water they drink and cause disease in them. Such diseases are much more likely to spread in the absence of safe supplies of drinking water.

The sexual act is one of the closest physical contact two people can have with each other. Not surprisingly, there are microbial diseases such as syphilis or AIDS that are transmitted by sexual contact from one partner to the other. However, such sexually transmitted diseases are not spread by casual physical contact. Casual physical contacts include handshakes or hugs or sports, like wrestling, or by any of the other ways in which we touch each other socially. Other than the sexual contact, the AIDS virus can also spread through blood-to-blood contact with infected people or from an infected mother to her baby during pregnancy or through breast feeding.

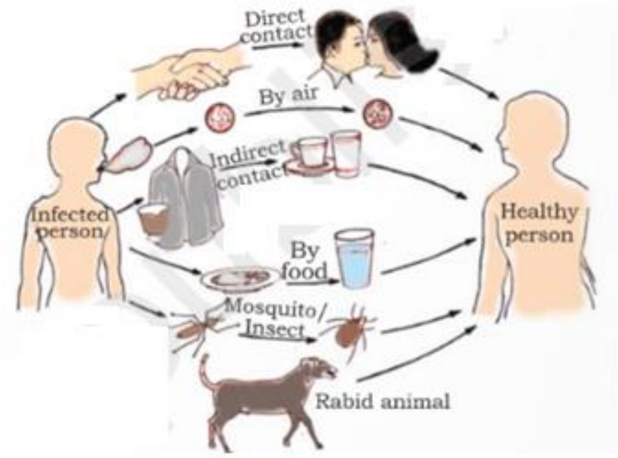

Fig 1.3*: Common method of transmission of diseases.*

We live in an environment that is full of many other creatures apart from us. It is inevitable that many diseases will be transmitted by other animals. These animals carry the infecting agents from a sick person to another potential host. These animals are thus the intermediaries and are called vectors. The commonest vectors we all know are mosquitoes. In many species of mosquitoes, the females need highly nutritious food in the form of blood in order to be able to lay mature eggs. Mosquitoes feed on many warm-blooded animals, including us. In this way, they can transfer diseases from person to person.

1.3.3 Organ-specific and tissuespecific manifestations

The disease-causing microbes enter the body through these different means. Where do they go then? The body is very large when compared to the microbes. So there are many possible places, organs or tissues, where they could go. Do all microbes go to the same tissue or organ, or do they go to different ones?

Different species of microbes seem to have evolved to home in on different parts of the body. In part, this selection is connected to their point of entry. If they enter from the air via the nose, they are likely to go to the lungs. This is seen in the bacteria causing tuberculosis. If they enter through the mouth, they can stay in the gut lining like typhoid causing bacteria. Or they can go to the liver, like the viruses that cause jaundice.

But this needn't always be the case. An infection like HIV, that comes into the body via the sexual organs, will spread to lymph nodes all over the body. Malaria-causing microbes, entering through a mosquito bite, will go to the liver, and then to the red blood cells. The virus causing Japanese encephalitis, or brain fever, will similarly enter through a mosquito bite. But it goes on to infect the brain.

The signs and symptoms of a disease will thus depend on the tissue or organ which the microbe targets. If the lungs are the targets, then symptoms will be cough and breathlessness. If the liver is targeted, there will be jaundice. If the brain is the target, we will observe headaches, vomiting, fits or unconsciousness. We can imagine what the symptoms and signs of an infection will be if we know what the target tissue or organ is, and the functions that are carried out by this tissue or organ.

In addition to these tissue-specific effects of infectious disease, there will be other common effects too. Most of these common effects depend on the fact that the body's immune system is activated in response to infection. An active immune system recruits many cells to the affected tissue to kill off the disease-causing microbes. This recruitment process is called inflammation. As a part of this process, there are local effects such as swelling and pain, and general effects such as fever.

In some cases, the tissue-specificity of the infection leads to very general-seeming effects. For example, in HIV infection, the virus goes to the immune system and damages its function. Thus, many of the effects of HIV-AIDS are because the body can no longer fight off the many minor infections that we face everyday. Instead, every small cold can become pneumonia. Similarly, a minor gut infection can produce major diarrhoea with blood loss. Ultimately, it is these other infections that kill people suffering from HIV-AIDS.

It is also important to remember that the severity of disease manifestations depend on the number of microbes in the body. If the number of microbes is very small, the disease manifestations may be minor or unnoticed. But if the number is of the same microbe large, the disease can be severe enough to be life-threatening. The immune system is a major factor that determines the number of microbes surviving in the body. We shall look into this aspect a little later in the chapter.

1.3.4 Principles of treatment

What are the steps taken by your family when you fall sick? Have you ever thought why you sometimes feel better if you sleep for some time? When does the treatment involve medicines?

Based on what we have learnt so far, it would appear that there are two ways to treat an infectious disease. One would be to reduce the effects of the disease and the other to kill the cause of the disease. For the first, we can provide treatment that will reduce the symptoms. The symptoms are usually because of inflammation. For example, we can take medicines that bring down fever, reduce pain or control loose motions. We can take bed rest so that we can conserve our energy. This will enable us to have more of it available to focus on healing.

But this kind of symptom-directed treatment by itself will not make the infecting microbe go away and the disease will not be cured. For that, we need to be able to kill off the microbes.

How do we kill microbes? One way is to use medicines that kill microbes. We have seen earlier that microbes can be classified into different categories. They are viruses, bacteria, fungi or protozoa. Each of these groups of organisms will have some essential biochemical life process which is peculiar to that group and not shared with the other groups. These processes may be pathways for the synthesis of new substances or respiration.

These pathways will not be used by us either. For example, our cells may make new substances by a mechanism different from that used by bacteria. We have to find a drug that blocks the bacterial synthesis pathway without affecting our own. This is what is achieved by the antibiotics that we are all familiar with. Similarly, there are drugs that kill protozoa such as the malarial parasite.

One reason why making anti-viral medicines is harder than making antibacterial medicines is that viruses have few biochemical mechanisms of their own. They enter our cells and use our machinery for their life processes. This means that there are relatively few virus-specific targets to aim at. Despite this limitation, there are now effective anti-viral drugs, for example, the drugs that keep HIV infection under control.

1.3.5 Principles of prevention

All of what we have talked about so far deals with how to get rid of an infection in someone who has the disease. But there are three limitations of this approach to dealing with infectious disease. The first is that once someone has a disease, their body functions are damaged and may never recover completely. The second is that treatment will take time, which means that someone suffering from a disease is likely to be bedridden for some time even if we can give proper treatment. The third is that the person suffering from an infectious disease can serve as the source from where the infection may spread to other people. This leads to the multiplication of the above difficulties. It is because of such reasons that prevention of diseases is better than their cure. How can we prevent diseases? There are two ways, one general and one specific to each disease. The general ways of preventing infections mostly relate to preventing exposure. How can we prevent exposure to infectious microbes?

If we look at the means of their spreading, we can get some easy answers. For airborne microbes, we can prevent exposure by providing living conditions that are not overcrowded. For water-borne microbes, we can prevent exposure by providing safe drinking water. This can be done by treating the water to kill any microbial contamination. For vector-borne infections, we can provide clean environments. This would not, for example, allow mosquito breeding. In other words, public hygiene is one basic key to the prevention of infectious diseases.

In addition to these issues that relate to the environment, there are some other general principles to prevent infectious diseases. To appreciate those principles, let us ask a question we have not looked at so far. Normally, we are faced with infections everyday. If someone is suffering from a cold and cough in the class, it is likely that the children sitting around will be exposed to the infection. But all of them do not actually suffer from the disease. Why not?

This is because the immune system of our body is normally fighting off microbes. We have cells that specialise in killing infecting microbes. These cells go into action each time infecting microbes enter the body. If they are successful, we do not actually come down with any disease. The immune cells manage to kill off the infection long before it assumes major proportions. As we noted earlier, if the number of the infecting microbes is controlled, the manifestations of disease will be minor. In other words, becoming exposed to or infected with an infectious microbe does not necessarily mean developing noticeable disease.

So, one way of looking at any severe infectious disease is that it represents a lack of success of the immune system. The functioning of the immune system, like any other system in our body, will not be good if proper and sufficient nourishment and food is not available. Therefore, the second basic principle of prevention of infectious disease is the availability of proper and sufficient food for everyone.

Activity 1.6

- Conduct a survey in your locality. Talk to ten families who are well-off and ten who are very poor (in your estimation). Both sets of families should have children who are below five years of age. Measure the heights of these children. Draw a graph of the height of each child against its age for both sets of families.
- Is there a difference between the groups? If yes, why?
- If there is no difference, do you think that your findings mean that being well-off or poor does not matter for health?

These are the general ways of preventing infections. What are the specific ways? They relate to a peculiar property of the immune system that usually fights off microbial infections. Let us cite an example to try and understand this property.

These days, there is no smallpox anywhere in the world. But as recently as a hundred years ago, smallpox epidemics were not at all uncommon. In such an epidemic, people used to be very afraid of coming near someone suffering from the disease since they were afraid of catching the disease.
However, there was one group of people who did not have this fear. These people would provide nursing care for the victims of smallpox. This was a group of people who had had smallpox earlier and survived it, although with a lot of scarring. In other words, if you had smallpox once, there was no chance of suffering from it again. So, having the disease once was a means of preventing subsequent attacks of the same disease.
This happens because when the immune system first sees an infectious microbe, it responds against it and then remembers it specifically. So the next time that particular microbe, or its close relatives enter the body, the immune system recognises it and responds with even
greater vigour. This eliminates the infection even more quickly than the first time around. This is the basis of the principle of immunisation.

Immunisation

Traditional Indian and Chinese medicinal systems sometimes deliberately rubbed the skin crusts from smallpox victims into the skin of healthy people. They thus hoped to induce a mild form of smallpox that would create resistance against the disease. Famously, two centuries ago, an English physician named Edward Jenner, realised that milkmaids who had had cowpox did not catch smallpox even during epidemics. Cowpox is a very mild disease. Jenner tried deliberately giving cowpox to people (as he can be seen doing in the picture), and found that they were now resistant to smallpox. This was because the smallpox virus is closely related to the cowpox virus. 'Cow' is 'vacca' in Latin, and cowpox is 'vaccinia'. From these roots, the word 'vaccination' has come into our usage.

We can now see that, as a general principle, we can 'fool' the immune system into developing a memory for a particular infection by putting something, that mimics the microbe we want to vaccinate against, into the body. This does not actually cause the disease but this would prevent any subsequent exposure to the infecting microbe from turning into actual disease.
Many such vaccines are now available for preventing a whole range of infectious diseases, and provide a disease-specific means of prevention. There are vaccines against tetanus, diphtheria, whooping cough, measles, polio and many others. These form the public health programme of childhood immunisation for preventing infectious diseases.
Of course, such a programme can be useful only if such health measures are available to all children. Can you think of reasons why this should be so? Some hepatitis viruses,

which cause jaundice, are transmitted through water. There is a vaccine for one of them, hepatitis A, in the market. But the majority of children in many parts of India are already immune to hepatitis A by the time they are five years old. This is because they are exposed to the virus through water. Under these circumstances, would you take the vaccine?

Activity 1.7

- Rabies virus is spread by the bite of infected dogs and other animals. There are anti-rabies vaccines for both humans and animals. Find out the plan of your local authority for the control of rabies in your neighbourhood. Are these measures adequate? If not, what improvements would you suggest?

Questions

1. *Why are we normally advised to take bland and nourishing food when we are sick?*
2. *What are the different means by which infectious diseases are spread?*
3. *What precautions can you take in your school to reduce the incidence of infectious diseases?*
4. *What is immunisation?*
5. *What are the immunisation programmes available at the nearest health centre in your locality? Which of these diseases are the major health problems in your area?*

(Source: NCERT Text Book Dec. 2017)

Section 2

Conservation of Momentum

Suppose two objects (two balls A and B, say) of masses m_A and m_B are travelling in the same direction along a straight line at different velocities u_A and u_B, respectively [Fig. 2.1 (a)]. And there are no other external unbalanced forces acting on them. Let $u_A > u_B$ and the two balls collide with each other as shown in Fig. 2.1 (b). During collision which lasts for a time t, the ball A exerts a force F_{AB} on ball B and the ball B exerts a force F_{BA} on ball A. Suppose v_A and v_B are the velocities of the two balls A and B after the collision, respectively [Fig. 2.1 (c)].

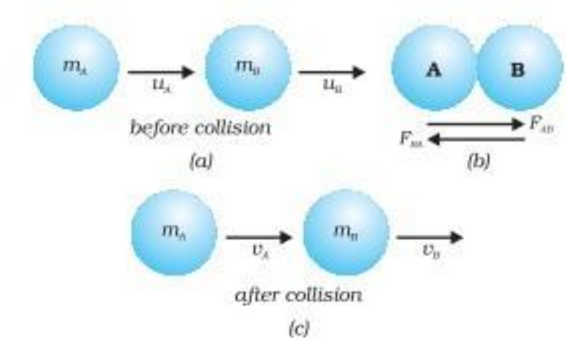

Fig 2.1 : Conservation of momentum in collision of two balls.

From Eq. ($p = mv$), the momenta (plural of momentum) of ball A before and after the collision are $m_A u_A$ and $m_A v_A$, respectively. The rate of change of its momentum (or F_{AB}, action) during the collision will be $m_A \frac{(v_A - u_A)}{t}$. Similarly, the rate of change of momentum of ball B (= F_{BA} or reaction) during the collision will be $m_B \frac{(v_B - u_B)}{t}$. According to the third law of motion, the force F_{AB} exerted by ball A on ball B (action) and the force F_{BA} exerted by the ball B on ball A (reaction) must be equal and opposite to each other. Therefore,

$$F_{AB} = -F_{BA}$$

$$\text{or} \quad m_A \frac{(v_A - u_A)}{t} = -m_B \frac{(v_B - u_B)}{t}. \qquad \text{(i)}$$

This gives,

$$m_A u_A + m_B u_B = m_A v_A + m_B v_B \qquad \text{(ii)}$$

Since ($m_A u_A + m_B u_B$) is the total momentum of the two balls A and B before the collision and ($m_A v_A + m_B v_B$) is their total momentum after the collision, from Eq. (ii) we observe that the total momentum of the two balls remains unchanged or conserved provided no other external force acts. As a result of this ideal collision experiment, we say that the sum of momenta of the two objects before collision is equal to the sum of momenta after the collision provided there is no external unbalanced force acting on them. This is known as the law of conservation of momentum. This statement can alternatively be given as the total momentum of the two objects is unchanged or conserved by the collision.

Activity

- Take a big rubber balloon and inflate it fully. Tie its neck using a thread. Also using adhesive tape, fix a straw on the surface of this balloon.
- Pass a thread through the straw and hold one end of the thread in your hand or fix it on the wall.
- Ask your friend to hold the other end of the thread or fix it on a wall at some distance. This arrangement is shown in Fig. 2.2.
- Now remove the thread tied on the neck of balloon. Let the air escape from the mouth of the balloon.
- Observe the direction in which the straw moves.

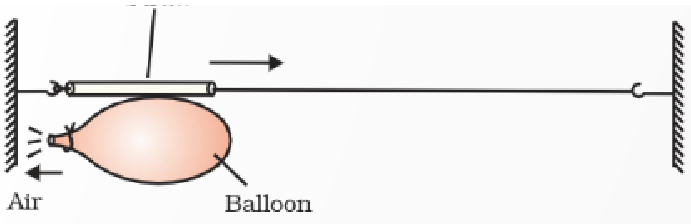

Fig 2.2

Activity

- Take a test tube of good quality glass material and put a small amount of water in it. Place a stop cork at the mouth of it.
- Now suspend the test tube horizontally by two strings or wires as shown in Fig. 2.3.
- Heat the test tube with a burner until water vaporises and the cork blows out.
- Observe that the test tube recoils in the direction opposite to the direction of the cork.
- Also, observe the difference in the velocity the cork appears to have and that of the recoiling test tube.

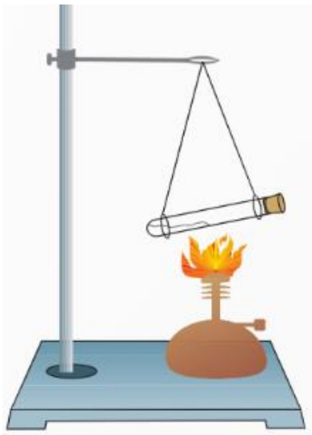

Fig 2.3

Example 1

A bullet of mass 20 g is horizontally fired with a velocity 150 m s^{-1} from a pistol of mass 2 kg. What is the recoil velocity of the pistol?

Solution: We have the mass of bullet, m_1 = 20 g (= 0.02 kg) and the mass of the pistol, m_2 = 2 kg; initial velocities of the bullet (u_1) and pistol (u_2) = 0, respectively. The final velocity of the bullet, v_1 = + 150 m s^{-1}. The direction of bullet is taken from left to right (positive, by convention, Fig. 1.4). Let v be the recoil velocity of the pistol. Total momenta of the pistol and bullet before the fire, when the gun is at rest

$= (2 + 0.02)\ \text{kg} \times 0\ \text{m s}^{-1}$

$= 0$ kg m s^{-1}

Total momenta of the pistol and bullet after it is fired

$= 0.02$ kg × (+ 150 m s_{-1}) + 2 kg × v m s_{-1} = (3 + 2v) kg m s_{-1}

According to the law of conservation of momentum

Total momenta after the fire = Total momenta before the fire

$3 + 2v = 0 \Rightarrow v = -1.5$ m s^{-1}.

Negative sign indicates that the direction in which the pistol would recoil is opposite to that of bullet, that is, right to left.

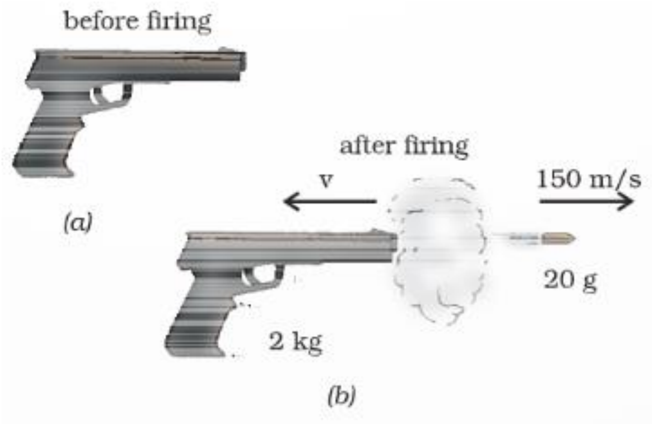

Fig. 2.4: Recoil of a pistol

Example 2

A girl of mass 40 kg jumps with a horizontal velocity of 5 m s^{-1} onto a stationary cart with frictionless wheels. The mass of the cart is 3 kg. What is her velocity as the cart starts moving? Assume that there is no external unbalanced force working in the horizontal direction.

Solution:

Let v be the velocity of the girl on the cart as the cart starts moving. The total momenta of the girl and cart before the interaction

$= 40$ kg × 5 m s^{-1} + 3 kg × 0 m s^{-1} = 200 kg m s^{-1}.

Total momenta after the interaction

= (40 + 3) kg × v m s^{-1} = 43 v kg m s^{-1}.

According to the law of conservation of momentum, the total momentum is conserved during the interaction. That is,

$43\,v = 200 \Rightarrow v = 200/43 = +4.65$ m s^{-1}.

The girl on cart would move with a velocity of 4.65 m s^{-1} in the direction in Fig. 2.4:

Recoil of a pistol which the girl jumped (Fig. 2.5).

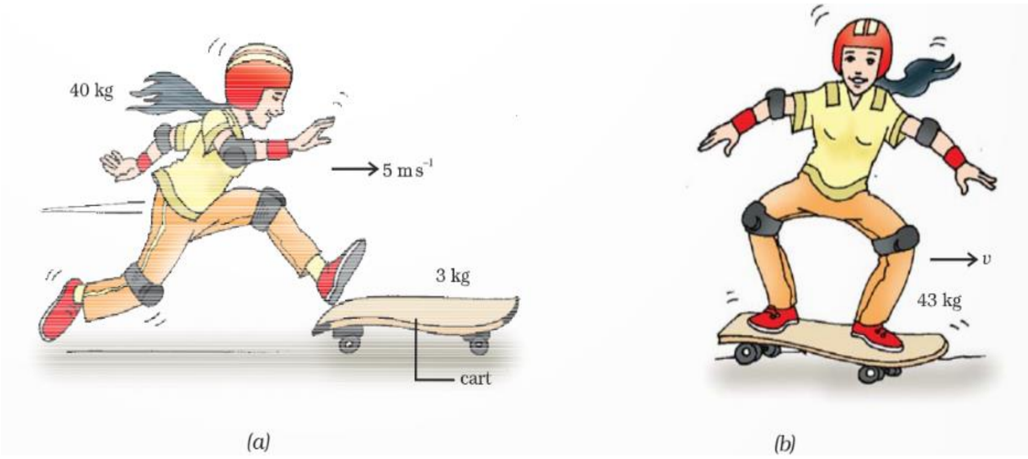

Fig. 2.5 The girl jumps onto the cart.

Example 3

Two hockey players of opposite teams, while trying to hit a hockey ball on the ground collide and immediately become entangled. One has a mass of 60 kg and was moving with a velocity 5.0 m s^{-1} from left to right while the other has a mass of 55 kg and was moving faster with a velocity 6.0 m s^{-1} towards the first player. In which direction and with what velocity will they move after they become entangled? Assume that the frictional force acting between the feet of the two players and ground is negligible.

Solution: If v is the velocity of the two entangled players after the collision, the total momentum then

$= (m_1 + m_2) \times v$

$= (60 + 55)$ kg × v m s^{-1}

$= 115 \times v$ kg m s^{-1}.

Let the first player be moving from left to right. By convention left to right is taken as the positive direction and thus right to left is the negative direction (Fig. 2.6). If symbols *m* and *u* represent the mass and initial velocity of the two players, respectively. Subscripts 1 and 2 in these physical quantities refer to the two hockey players. Thus,
m_1 = 60 kg; u_1 = + 5 m s^{-1}; and
m_2 = 55 kg; u_2 = – 6 m s^{-1}.
The total momentum of the two players before the collision
= 60 kg X (+ 5 m s^{-1}) + 55 kg X (– 6 m s^{-1})
= – 30 kg m s^{-1}

Equating the momenta of the system before and after collision, in accordance with the law of conservation of momentum, we get

v = – 30/115

= – 0.26 m s^{-1}. Thus, the two entangled players would move with velocity 0.26 m s^{-1} from right to left, that is, in the direction the second player was moving before the collision.

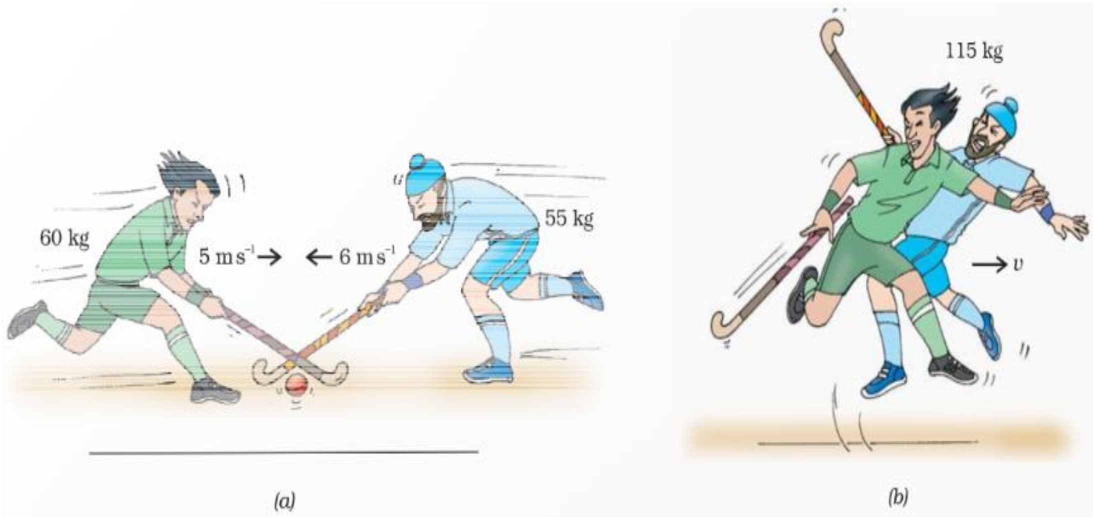

Fig. 2.6: A collision of two hockey players: (a) before collision and (b) after collision.

Questions

1. *If action is always equal to the reaction, explain how a horse can pull a cart.*
2. *Explain, why is it difficult for a fireman to hold a hose, which ejects large amounts of water at a high velocity.*
3. *From a rifle of mass 4 kg, a bullet of mass 50* g *is fired with an initial velocity of 35* m s^{-1}*. Calculate the initial recoil velocity of the rifle.*
1. *Two objects of masses 100* g *and 200* g *are moving along the same line and direction with velocities of 2* m s^{-1} *and 1* m s^{-1}*, respectively. They collide and after the collision, the first object moves at a velocity of 1.67* m s^{-1}. *Determine the velocity of the second object.*

CONSERVATION LAWS

All conservation laws such as conservation of momentum, energy, angular momentum, charge etc. are considered to be fundamental laws in physics. These are based on observations and experiments. It is important to remember that a conservation law cannot be proved. It can be verified, or disproved, by experiments. An experiment whose result is in conformity with the law verifies or substantiates the law; it does not prove the law. On the other hand, a single experiment whose result goes against the law is enough to disprove it.

The law of conservation of momentum has been deduced from large number of observations and experiments. This law was formulated nearly three centuries ago. It is interesting to note that not a single situation has been realised so far, which contradicts this law. Several experiences of every-day life can be explained on the basis of the law of conservation of momentum.

(Source: NCERT Text Book Dec. 2017)